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L. O. HOWARD, Chief

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CYPRESS BARK SCALE.[1]

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CONTENTS.

	Page.		Page.
Economic importance	1	Descriptions	8
History	2	Life history and habits	12
Native host plant	2	Seasonal history	16
Distribution and spread	3	Predacious and parasitic enemies	18
Injury	4	Control experiments	19
Associated insects	7	Recommendations for control	20
Food plants	8	Summary	22

ECONOMIC IMPORTANCE.

The Monterey cypress (*Cupressus macrocarpa* Hartw.) is one of the most popular shade and ornamental trees in California. It is planted separately or in hedgerows and often trimmed to formal shapes. Due to its thick, spreading habits it makes a good windbreak where it is planted in exposed areas. It is used especially along the coast and in the sandy citrus areas of San Bernardino County. It is also cultivated as an ornamental tree in many other parts of the world.

The cypress bark scale infests a large percentage of these trees in California, causing a great deal of injury, particularly to the thickly planted hedgerows (Pl. I, figs. 1, 2) and windbreaks. In the San Francisco Bay region it ranks first among the pests of the

[1] *Ehrhornia cupressi* (Ehrhorn). Order Hemiptera, suborder Homoptera, family Coccidae.

NOTE.—An investigation of the injury to cypress trees in California was taken up by the writer, at the suggestion of Dr. A. D. Hopkins, Forest Entomologist, in November, 1916. An examination made of these trees in the vicinity of the Los Gatos laboratory disclosed the main cause of the injury to be the cypress bark scale, *Ehrhornia cupressi* (Ehrhorn). This bulletin contains a record of studies of its history, biology, importance, and control made during this investigation.

The writer wishes to acknowledge the assistance of Dr. A. D. Hopkins, Forest Entomologist; Mr. H. E. Burke, Specialist in Forest Entomology; Prof. R. W. Doane and Mr. G. F. Ferris, of the Stanford University Department of Entomology; and Mr. George P. Gray, of the University of California Insecticide Laboratory, all of whom offered helpful suggestions during this study. Mr. R. D. Hartman assisted in the control experiments.

Monterey cypress. The insect is extremely difficult to control—a fact which makes it a very disagreeable and harmful pest.

HISTORY.

The cypress bark scale was first described in 1911 as *Sphaerococcus cupressi* by Mr. E. M. Ehrhorn[1] who collected it at Niles and San Jose, Calif., as early as 1903, and at Belvedere, Calif., in 1908, in the bark crevices of Monterey cypress. The next mention of this insect was in the report of the Selby Smelter Commission in 1915, when Mr. J. W. Blankinship[2] and Prof. R. W. Doane[2] reported it as one of the factors causing the death and dilapidation of the Monterey cypress in the Selby smoke zone. In October, 1918, Mr. G. F. Ferris,[3] with the writer's approval, erected a new genus, Ehrhornia, for this species, for it certainly was not a Sphaerococcus. Although an important shade-tree pest, no discussion of this insect has appeared in print otherwise, except for a short note by the writer[4] on its damage and distribution.

This coccid has no synonyms, having been listed under the name *Sphaerococcus cupressi* until the new genus, Ehrhornia, was erected in 1918, with *cupressi* as the type.

NATIVE HOST PLANT.

This scale insect could not be found at Cypress Point or Point Lobos, Calif., the only localities where the Monterey cypress is native, which showed quite conclusively that this tree was not the native host.

On November 9, 1917, the cypress bark scale was found infesting some planted trees of Arizona cypress (*Cupressus arizonica*) at San Jose, Calif., although it has not at the present writing been found on the native cypress in Arizona.

On December 6, 1917, this insect was found by the writer infesting one incense cedar (*Libocedrus decurrens*), and later several more trees, on the Stanford University campus. Later, the native incense cedars at Placerville, Calif., were examined. A number of them were found infested. They were several miles from any planted cypresses, which, moreover, were not infested.

Later, the cypress bark scale was found upon incense cedar at Ashland, Oreg., by Mr. Albert Wagner, of the United States Bureau of Entomology; at Crockers, Calif., by Mr. G. F. Ferris; and at

[1] EHRHORN, E. M. NEW COCCIDÆ WITH NOTES ON OTHER SPECIES. *In* Can. Ent., v. 43, no. 8, p. 275–280. (Figs. 3, 3a, b, c.) 1911.

[2] HOLMES, J. A., FRANKLIN, E. C., GOULD, R. A. REPORT OF THE SELBY SMELTER COMMISSION. U. S. Dept. Int., Bur. of Mines, Bul. 98, p. 381–597; 428–450. 1915.

[3] FERRIS, G. F. NOTES ON COCCIDÆ II. *In* Can. Ent. v. 50, no. 10, p. 323–332. 1916.

[4] MONTHLY LETTER OF THE BUREAU OF ENTOMOLOGY, U. S. Dept. Agr., no. 46, p. 5. February, 1918.

Stirling City and Giant Forest, Calif., by the writer. These localities are all from 75 to 150 miles apart and from 5 to 50 miles distant from any planted cypress. This seems to indicate that the incense cedar is the native host for this scale insect.

Mr. G. F. Ferris reports finding this scale insect upon herbarium specimens of Guadalupe cypress (*C. guadalupensis*) in the Stanford University herbarium, collected on Guadalupe Island, Mexico. It is impossible at present to state whether this is one of the native hosts of the scale, or whether the scale has been carried there from the mainland.

DISTRIBUTION AND SPREAD.

Incense cedar, the original host plant of the cypress bark scale, occurs in California, Oregon, western Nevada, and Lower California. The majority of these trees are found in the Sierra Nevada and northern coast range mountains of California, and in the Siskiyou, southern coast range, and Cascade Mountains of Oregon.

The cypress bark scale has been found at four widely separated points in the Sierra Nevadas (Stirling City, Placerville, Crockers, and Giant Forest, Calif.) and at one point in the Siskiyou Mountains (Ashland, Oreg.), which indicates that the scale undoubtedly occurs throughout the major portion of the range of the original host.

From this host the scale insect has spread to planted incense cedars and cypresses in the more thickly populated regions of the State. Two probable methods of distribution are suggested.

The cypress bark scale has been found to thrive on very young trees. Incense cedar seedlings occasionally are brought down from the Sierra Nevadas by tourists to plant in their own yards, and it is quite possible that the scale was carried to the valley on some of these trees. Rustic incense cedar is also transported from the Sierra Nevadas to be used quite extensively for pergolas and porch pillars. Ordinarily this would be done during the summer, which is the reproductive period for the scale insect. As the females can live for some time on green logs, it would be very easy for the young larvæ, hatched en route or after the logs have reached their destination, to attach themselves to near-by cypress trees, and thus start a heavy infestation in a new location.

From these original points of infestation the pest has spread through large areas. This has been accomplished for short distances by the usual agencies of wind, birds, insects, etc., and for longer distances by the shipment of infested nursery stock. The insect has been found by the writer infesting cypress seedlings in nurseries. Close planting of shade trees, hedges, and windbreaks undoubtedly aids in its rapid spread by natural means.

The scale insect, besides being distributed on the incense cedar, has now spread until it occurs on a large percentage of the cypress trees and hedges in almost every locality about San Francisco Bay, particularly on the San Francisco Peninsula, in the Santa Clara and Livermore Valleys, and north of the bay in Solano, Marin, and Sonoma Counties. It has been found in one locality, Riverside, in southern California, where a great many trees are planted for windbreaks. It is also to be found on Guadalupe Island, Mexico, as it was recently taken from herbarium specimens of Guadalupe cypress collected on this island.

The accompanying map (fig. 1) indicates the localities in which the cypress bark scale has been found to date, as well as the range of incense cedar and Monterey cypress. There are many localities within the range of cypress and incense cedar, which the writer has not yet visited, in which the scale insect will probably be found, when investigated. In all probability it eventually will infest all planted cypresses unless radical measures of control are adopted.

Since it has been found that the cypress bark scale can live on Arizona cypress, it is possible that it may spread to that host in Arizona and Mexico, or it may even be able to adapt itself to closely related hosts and spread throughout the country.

INJURY.

Injury to the tree is caused by the myriads of insects which are to be found in every crack and crevice of the trunk, branches, and twigs, each sucking out the plant juice through its long thread-like mouth parts. Under each scale may be found a small brown ring in the cambium, showing the tissue killed by each individual.

There is no secretion of honeydew, except for a small amount by the young larvæ, and only a slight formation of black sooty fungus about these insects, but a secretion of white cottony wax protruding from the bark crevices and covering the twigs gives abundant evidence of their presence (Pl. II).

First a limb or two on an infested cypress turns yellow, then red or brown, giving the tree (Pl. III) a scraggy appearance. This appearance often starts near the top of the tree and works down toward the center, or perhaps spreads from one limb to the rest until the whole tree is dead. Quite often the trees are dug up or felled before this final stage is reached; others are left to mar the landscape until they rot and fall.

In hedges, yellow and red spots appear, which increase finally to large proportions, leaving wide gaps of dead material which eventually destroy the beauty of whole hedges. One hedge in Livermore, nearly a half mile long, was infested and dead or dying

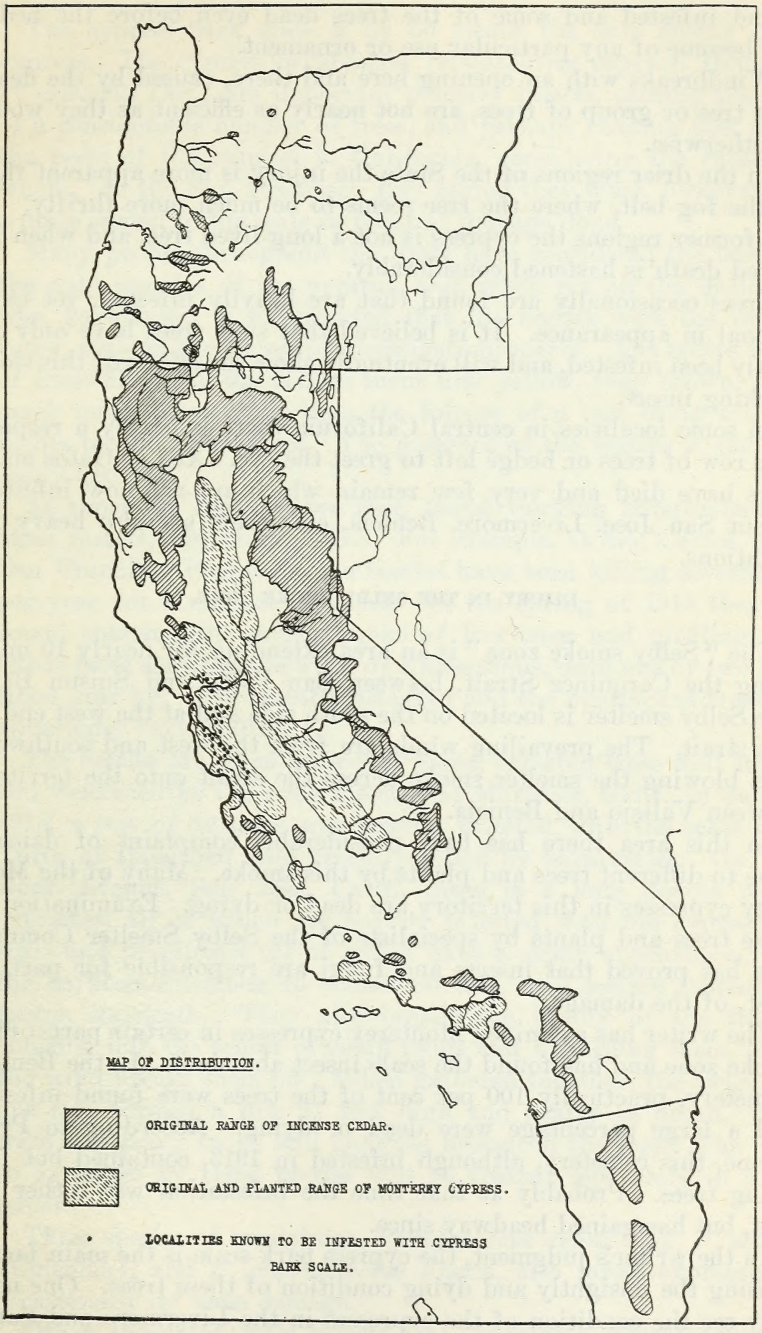

MAP OF DISTRIBUTION.
ORIGINAL RANGE OF INCENSE CEDAR.
ORIGINAL AND PLANTED RANGE OF MONTEREY CYPRESS.
LOCALITIES KNOWN TO BE INFESTED WITH CYPRESS BARK SCALE.

FIG. 1.—Map of distribution of the cypress bark scale.

for its full length. Young hedges but 3 or 4 years old have been found infested and some of the trees dead even before the hedge has become of any particular use or ornament.

Windbreaks with an opening here and there, caused by the death of a tree or group of trees, are not nearly as efficient as they would be otherwise.

In the drier regions of the State the injury is more apparent than in the fog belt, where the tree seems to be much more thrifty. In the former regions the cypress is not a long-lived tree, and when infested death is hastened considerably.

Trees occasionally are found that are heavily infested, yet quite normal in appearance. It is believed that such trees have only recently been infested, and will eventually show the effects of this slow-working insect.

In some localities in central California there is hardly a respectable row of trees or hedge left to greet the eye. At Los Gatos many trees have died and very few remain which are not now infested. About San Jose, Livermore, Benicia, etc., there are also heavy infestations.

INJURY IN THE SELBY SMOKE ZONE.

The "Selby smoke zone" is an area extending for nearly 10 miles along the Carquinez Strait, between San Pablo and Suisun Bays. The Selby smelter is located on the south side and at the west end of this strait. The prevailing winds are from the west and southwest, thus blowing the smelter smoke across the strait onto the territory between Vallejo and Benicia.

In this area there has been considerable complaint of damage done to different trees and plants by this smoke. Many of the Monterey cypresses in this territory are dead or dying. Examination of these trees and plants by specialists of the Selby Smelter Commission has proved that insects and fungi are responsible for part, at least, of the damage.

The writer has examined Monterey cypresses in certain parts of the smoke zone and has found the scale insect abundant. In the Benicia Cemetery, practically 100 per cent of the trees were found infested and a large percentage were dead or dying. According to Prof. Doane, this cemetery, although infested in 1913, contained but few dying trees. Probably at that time the infestation was rather recent, but has gained headway since.

In the writer's judgment, the cypress bark scale is the main factor causing the unsightly and dying condition of these trees. One need only see the condition of the cypresses in the Livermore and Santa Clara Valleys to reach this conclusion.

ASSOCIATED INSECTS.

The cypress bark scale is by no means the only enemy of the cypress. The cypress barkbeetles (*Phloeosinus cupressi* Hopk. and *P. cristatus* Lec.) are important primary insects, causing the death of a considerable number of trees, and perhaps ranking first among the pests of the cypress in California, considering the State as a whole. In the San Francisco Bay region they must, however, take a place second to the scale in point of damage done.

Many people throughout the State have considered the beetles as the only enemies of the cypress, and, when noting the death of a tree, have taken it for granted that the beetles were the primary cause, without bothering to investigate properly. The entire foliage of trees killed by the beetles turns first yellow, then brown, and is much more conspicuous than the foliage of a tree being killed by inches by the scale insect. The presence of the beetles is also more easily detected.

At times the beetles have been found working independently of other insects, and killing trees. For example, at San Carlos, on the San Francisco Peninsula, the beetles have been killing several trees per year for a number of years. In the spring of 1918 they were found entering the green trunks of live trees and girdling them. Other trees showing the work of Phloeosinus, dead one or two years, stood near by. The recently attacked and the unattacked trees were apparently very healthy.

The beetles are often secondary pests, entering trees well infested and weakened by the scale insect. At Martinez, Calif., in January, 1918, a row of 12 trees was heavily infested with the scale insect. Three of these had been recently killed by barkbeetles. On Alum Rock Avenue, San Jose, Calif., there is a long double row of cypresses, all of which are heavily infested with the cypress bark scale and practically all of which have a sickly appearance. Here the barkbeetles attack an occasional tree, or a section thereof, and hasten its death. They also impair the beauty of the trees by entering into the center of small twigs and weakening them, so that the wind breaks them off. When gathered together, the twigs from one tree formed a pile 2½ feet high and nearly as broad. There were also many twigs still hanging broken in the tree. The injury to cypresses by these beetles will be treated separately in a later paper.

Three species of mealybugs, *Pseudococcus ryani* Coq., *P. sequoiae* (Coleman), and *P. cupressicolus* Ferris, also infest cypresses and occasionally do some damage.

Other associated scale insects are *Xylococcus macrocarpae* Coleman, *Lecanium corni* Bouché, *Diaspis carueli* Targ., *Aspidiotus*

hederae (Vallot), and *Aspidiotus ehrhorni* Coleman. None of these have been noted doing any considerable damage.

Still other associated insects of various orders are: *Phymatodes nitidus* Lec., *Atimia confusa* Say, *Trachykele blondeli* Mars., the cypress moth (*Argyresthia cupressella* Wals.), the cypress cone-borer (*Cydia cupressana* Kear.), a horn-tail wasp (*Sirex californicus* Ashm.), the arborvitæ plant-louse (*Lachniella tujafilina* Del Guer.), and an undetermined tussock moth.

FOOD PLANTS.

The known food plants of the cypress bark scale are: Monterey cypress (*Cupressus macrocarpa* Hartw.), Arizona cypress (*C. arizonica* Greene), Guadalupe cypress (*C. guadalupensis* Wats.), and incense cedar (*Libocedrus decurrens* Torr.). On one other tree, a deodar cedar (*Cedrus deodara* Loud.), at Santa Rosa, Calif., a dead male was found in its cocoon.

It seems strange that the scale insect should not occur on all species of cypress if it will infest two trees as different as Monterey cypress and incense cedar, yet Italian and Oriental cypresses, two varieties of *Cupressus sempervirens*, are immune to the attack of this insect. They have been found in many instances in close proximity to infested Monterey cypresses and entirely free from the scale insect. In one case, in the Benicia Cemetery, 27 cypresses formed a square about a plot. Two-thirds of these were Monterey cypresses, with every third tree an Italian cypress, touching a Monterey cypress on each side. Every Monterey cypress was infested and dead or dying, while not a scale could be found on the Italian cypresses.

Specimens of Himalayan cypress (*C. torulosa* Don.), Macnab cypress (*C. macnabiana* Murray), funeral cypress (*C. funebris* Endl.), Sargent cypress (*C. sargentii* Jepson), and Port Orford cedar (*Chamaecyparis lawsoniana* (Murr.) Parl.) have been examined, although not in large numbers, within the infested areas, and no cypress bark scales could be found upon them.

DESCRIPTION.[1]

THE EGG.

Egg (Pl. IV, *A*), immediately after being deposited, regularly oval, smooth, and shiny, of a transparent pale yellow color, with eyes of embryo visible through membrane as two dark spots near one end. Average length of seven eggs 0.34; mm.; width 0.14.

LARVA.

FIRST INSTAR.

Young larvæ (Pl. IV, *B*) of both sexes alike. Pale yellow in color, with long, flat, oval bodies 0.43 mm. in length, 0.20 mm. in width. Antennæ (Pl. V,

[1] The following detailed description of all stages from the egg to adult, both male and female, were made from living and freshly mounted material collected during the study of the cypress bark scale.

FIG. 1.—A TALL MONTEREY CYPRESS HEDGE, SHOWING MANY DEAD SPOTS CAUSED BY THE CYPRESS BARK SCALE.

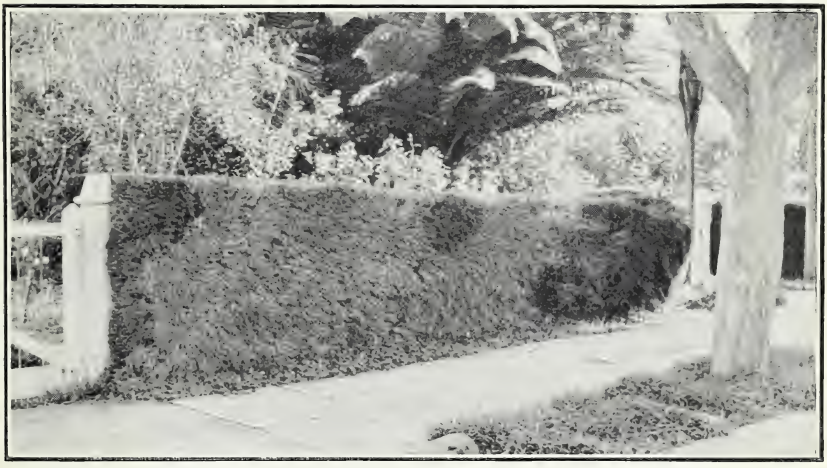


FIG. 2.—A MONTEREY CYPRESS HEDGE KILLED BY THE CYPRESS BARK SCALE.

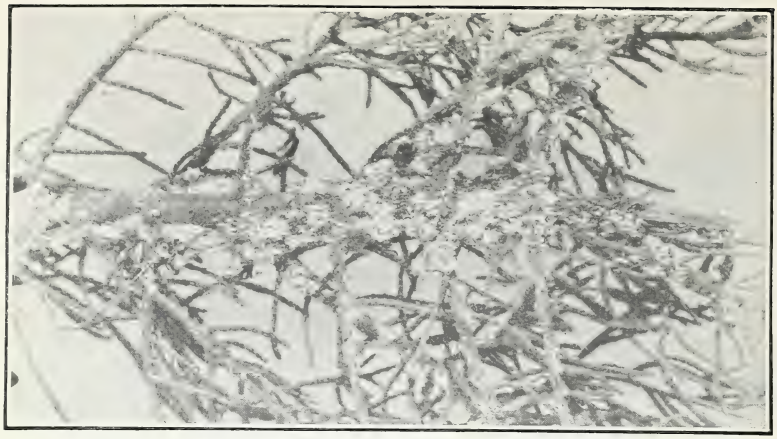


FIG. 1.—CHARACTERISTIC INFESTATION ON MONTEREY CYPRESS TWIG, SHOWING THE COTTONY EXCRETIONS OF THE CYPRESS BARK SCALE. × 0.4.

FIG. 2.—CHARACTERISTIC INFESTATION ON THE BARK, THE COTTONY EXCRETIONS OF THE CYPRESS BARK SCALE PROTRUDING FROM THE CREVICES. × 2.

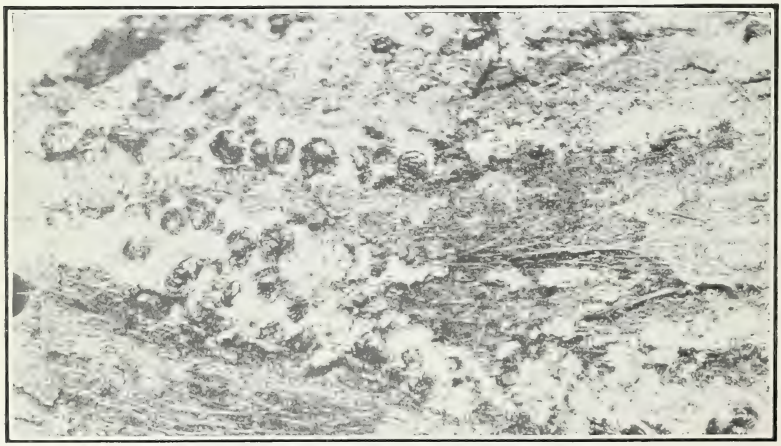
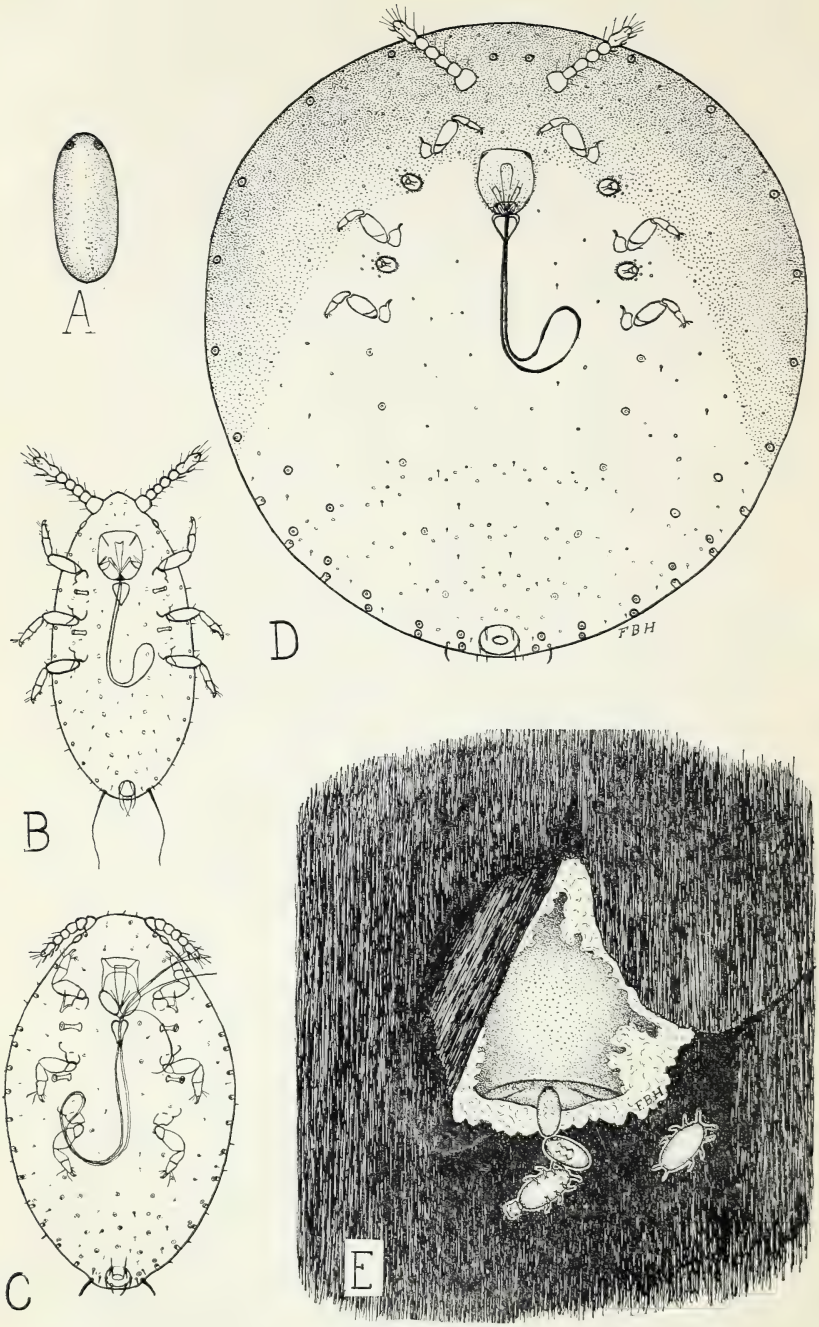


FIG. 3.—THE DRY OUTER PORTIONS OF THE BARK REMOVED, REVEALING THE FEMALES OF THE CYPRESS BARK SCALE UNDERNEATH. × 4.

FIG. 1.—A MONTEREY CYPRESS WHICH IS NEARLY DEAD FROM THE WORK OF THE CYPRESS BARK SCALE.

FIG. 2.—A ROW OF MONTEREY CYPRESSES, ALL OF WHICH ARE PRACTICALLY DEAD FROM A CYPRESS BARK SCALE INFESTATION.



THE CYPRESS BARK SCALE.

A, Egg (× 55); *B*, larva, first instar (× 85); *C*, female larva, second instar (× 55); *D*, adult female (× 55); *E*, portion of bark removed, showing adult female depositing eggs, the eggs hatching, and the larva crawling away.

A, 2) six-segmented, first segment broadest, sixth longest. Normal antennal formula as follows: 6, 1, (2, 4, 3, 5). Joints 2, 3, 4, 5 subequal and variable, thus causing various formulæ. Antennæ rather hairy. Fifth segment bearing one broad spine, while four occur on sixth segment. Eyes marginal, set a short distance behind antennæ. Legs rather short and stout. Tarsus slightly longer than tibia, the two combined slightly longer than femur and trochanter combined. Legs rather hairy, tarsi bearing four knobbed digitules. Usual coccid sucking mouthparts present. About 26 trilocular pores set rather regularly about margin and two longitudinal rows of the same type on dorsum of insect. Caudal setæ (Pl. V, *B*, 1) prominent, rather stout, and about 140 μ long; borne on small inconspicuous anal lobes. Anal ring bearing six setæ, noticeably longer than in later stages. A number of short spines scattered over body.

SECOND INSTAR.

Immediately after the first molt some differences between the sexes can be detected under the microscope. Toward the end of the second stage an external difference can be observed in the shape, the female being broader than the male.

Female larva (Pl. IV, *C*) about 0.84 mm. long and 0.51 mm. wide, oval in outline, yellowish brown in color. Legs and eyes similar to those of first-stage larva. Antennæ very similar except that sixth segment bears only two broad spines. Caudal setæ (Pl. V, *B*, 3) much shorter, being only 37 μ long. Anal ring still bearing six hairs, also shorter than in preceding stage. A larger number of tubular wax ducts, varying from 40 to 75, to be found on dorsum, particularly abdomen, and on lateral margin. Also a number of trilocular pores and small spines scattered over body.

Male larva (Pl. VI, *A*) about the same length but narrower than female; 0.85 mm. long by 0.43 mm. wide. Color yellowish. Caudal setæ twice as long as those of female, half as long as those of first-instar larva, 75μ. Six anal hairs, in length equaling diameter of anal ring; longer than those of second-stage female, but shorter than those of first-stage larva. Pores of male larva very inconspicuous (Pl. V, *D*, 2), smaller than those of female. Small quinquelocular type pores scattered over both dorsum and venter of body. Small tubular ducts found mostly on margin. Small spines also present.

ADULT FEMALE, THIRD INSTAR.

Body (Pl. IV, *D*) nearly circular and quite convex, the width exceeding the depth and the length exceeding the width. Average length 1.45 mm., average width 1.35 mm. General color reddish brown. Anterior half of body quite heavily chitinized, particularly on margin. Derm smooth.

Antennæ (Pl. V, *A*, 3) no longer marginal, but occurring on ventral side of body, six-segmented, slightly longer, averaging 144 μ, but similar to those of second-instar larva, bearing only two of the four spines found on sixth segment of first-instar larva. As in larva antennal formula varying considerably, of practically no value. Average formula as follows: 6, 1, 3, (5, 2, 4). Eyes lacking.

Legs (Pl. V, *C*, 1) short and stout. Tibia and tarsus (Pl. V, *C*, 2) subequal, being together slightly shorter than trochanter and femur combined. Leg bearing a few hairs and tarsus bearing four knobbed digitules. Usual coccid mouthparts present. Large tubular ducts (Pl. V, *D*, 1) occurring on margin and dorsum of body. Small trilocular pores and fine spines scattered over body, particularly on abdomen. Anal ring (Pl. V, *B*, 4) occurring on ventral side of body, small, simple, and with six small setæ or hairs. A pair of small caudal setæ one on each side of anus. Anal lobes absent.

MALE PREPUPA.

With the second molt, the male larva assumes the form of a partly developed pupa, called the prepupa (Pl. VI, *B*). Form elongate oval; length 0.93 mm., width 0.50 mm. Color pale glassy brown, eyes black. Antennæ short, reaching to base of anterior legs and now indistinctly 10 segmented. Wing pads very short, curving under body to middle pair of legs. Anterior legs reaching forward, covering "face," the two posterior pairs lying against abdomen. Mouth parts wanting. Segmentation of thorax indistinct. Prepupa incapable of movement, except in abdominal segments and anterior legs, which may be feebly moved.

MALE PUPA.

With the third molt, the male becomes a true pupa (Pl. VI, *C*), greatly resembling the adult male, except for the lack of anal wax filaments, and the possession of wing pads instead of wings. General color light brown, head and large, conspicuous wing pads paler, legs and antennæ glassy white, eyes black. Antennæ distinctly 10-segmented and longer, reaching to base of middle pair of legs. Wing pads appressed to sides of body and extending posteriorly to second abdominal segment. Legs capable of some movement, anterior pair extending beyond the head; middle femora placed transverse to and extending beyond lateral margin of body, rear pair inclining posteriorly. The larval eyes have disappeared, and have been replaced by one dorsal and one ventral pair. Mouth parts replaced by an approximate pair of eyes. Length 0.95 mm.; width 0.45 mm.

ADULT MALE.

(Pl. VI, *D, E.*)

Measurements of average adult male: Length of body (exclusive of appendages) 0.75 mm.; antennæ 0.55 mm.; wax filaments 0.93 mm.; wing expanse 2.15 mm. General color light brown with paler brown appendages.

Antennæ (Pl. V. *A*, 1) 10-segmented, rather hairy, first joint short and broad, second rather long and broad, others more slender. Antennal formula: 3, 4, 5, 6, 7, 8, 9 (10, 2), 1. Legs rather long, slender, and somewhat hairy. Wings transparent white, slightly iridescent and pubescent. A veinlike thickening, beginning at base of wing, branching near base, one branch paralleling costal margin, the other extending toward anal distal margin. Club-shaped halteres each bearing a hook, which catches in a pocket on anal margin of wing. Abdomen terminating in a short blunt style. Two long white wax filaments arising one on either side of base of style, and extending posteriorly. Each filament arising from a number of pores which surround base of two long slender setæ. Setæ enveloped by wax filaments.

SUMMARY.

As will be noted from the foregoing descriptions, there are three instars (excluding the egg) in the female. These all have legs, which are not used after the larva is attached. All stages are found in crevices or under some covering on the bark and are nearly or completely concealed by the enveloping cottony wax. Newly hatched first-instar larvæ may be found crawling actively over the bark before attachment.

There are five stages in the male. The first two stages are found in similar positions, but the second stage after becoming full grown re-

moves to a dry, secluded spot, where it spins a cocoon in which the remaining transformations take place.

Size and shape are of some use in distinguishing the different stages. The female in its second stage is considerably broader than the male in the second stage, while both are larger than in the first stage. The adult female is more circular than in the preceding stage.

The antennæ of the adult female are slightly longer than the antennæ of second-stage larvæ, while the latter are slightly longer than those of the first-stage larvæ. All are very similar, however, the only distinguishing character being that the first-stage larva possesses two more broad spines on the sixth segment.

The three pairs of legs on each individual are alike, nor is there any difference between the larvæ and the adult female, except a very slight one in the relative lengths of the femur, tibia, and tarsus. Mr. Ehrhorn's figures indicate a difference in the arrangement of the hairs and digitules, which the writer has been unable to detect. There is a very small, scarcely discernible, tooth or "denticle" on the face of the claw in all these stages.

The caudal setæ give good characters for the separation of the different stages. On the first-stage larva they are about 140 microns long; on the second-stage male they are about half as long, 75 microns; those of the second-stage female half as long as the latter, 37 microns; and those of the adult female very much shorter still. The length of the setæ on the anal ring also decreases in the same ratio.

Simple marginal eyes are present in all the larval stages, but not in the adult female. Mouth parts are present in all stages, except in the male prepupa, pupa, and adult.

Four spiracles are present in all the larvæ and the adult female, one behind each of the four forward legs. In the larvæ they appear as simple tubes, and more as large chitinized circles in the adult female.

There are several types of pores found on the derm of the scale insect, which aid in distinguishing the different stages. The small sessile pores are of two types, viz., "trilocular" (Pl. V, *D*, 4) and "quinquelocular" (Pl. V, *D*, 5). The former are more or less triangular and contain three cells or loculi. The quinquelocular pores are nearly circular, but tend to be five-sided, containing ordinarily six loculi, one in the center with five clustered about it. Aside from these there are circular pores communicating with internal ducts. These are short and tubular, bearing at the inner end a cup-shaped depression. All types are presumably capable of secreting wax.

The first-stage larva bears only small pores of the trilocular type. These are arranged in a marginal row on each side of the body and in two longitudinal rows on the dorsum.

On the second-stage female larva are to be found the small trilocular pores scattered over the body, and from 40 to 75 of the large tubular ducts on the margin and dorsum (particularly on the abdomen). The pores of the second-stage male larva are of two types: The small quinquelocular type which are found all over the body, and tubular ducts similar to those of the second-stage female larva, but much smaller and less conspicuous, found mostly on the margin.

The pores and ducts of the adult female are of the trilocular and tubular types, the first scattered over the body and the latter occurring on the margin and dorsum of the body, much the same as in the second-stage female larva.

Small spines (Pl. V, *D*, 3) are present on all these stages. Viewed from above, these spines are likely to have the appearance of circular pores, but can be soon distinguished by altering the focus of the microscope.

LIFE HISTORY AND HABITS.

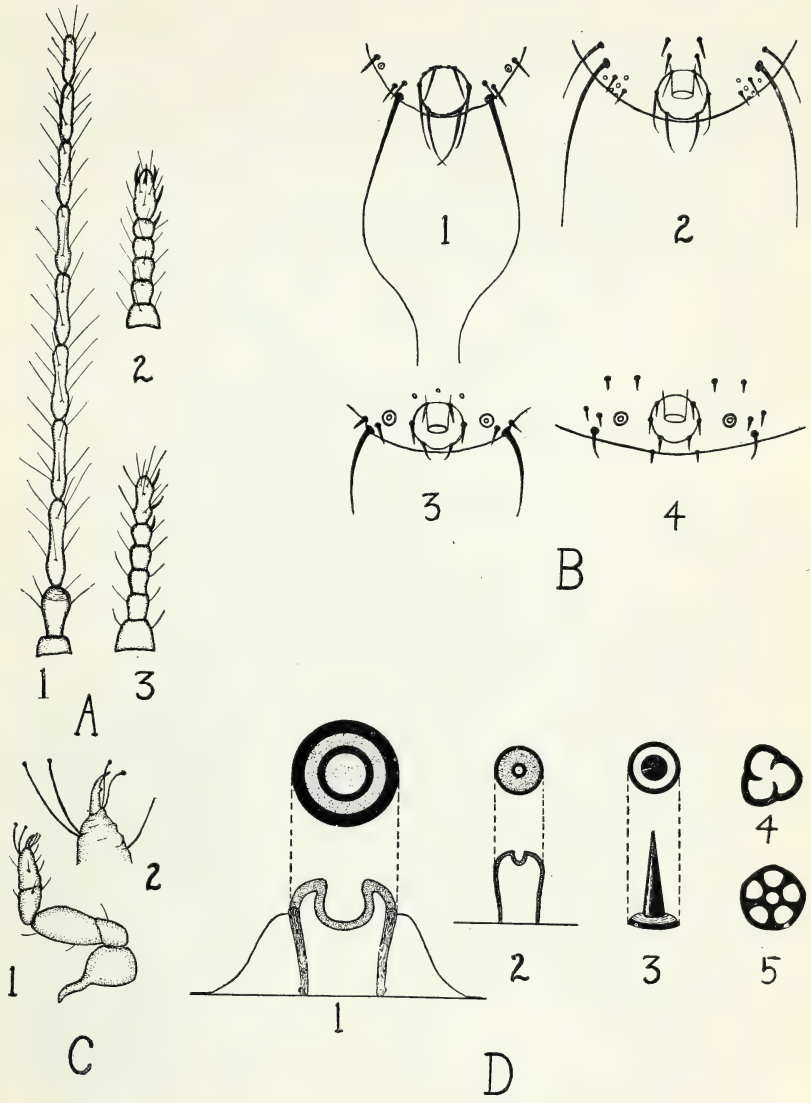
In the early winter adult females are found containing a few eggs. The eggs increase in number and by early spring from 30 to over 100 may be found within each female. During this time the females have increased considerably in size and have become quite heavily chitinized on the anterior half of the body.

OVIPOSITION.

The embryos in the eggs develop within the body of the female until they are about ready to hatch, when they are expelled (Pl. IV, *E*). The female is well surrounded by a cottony secretion, but when oviposition is begun the tip of the abdomen is drawn in, leaving a space in which the eggs may remain until hatched. After hatching, the larvæ are usually able to find an exit between the cotton and the surrounding bark.

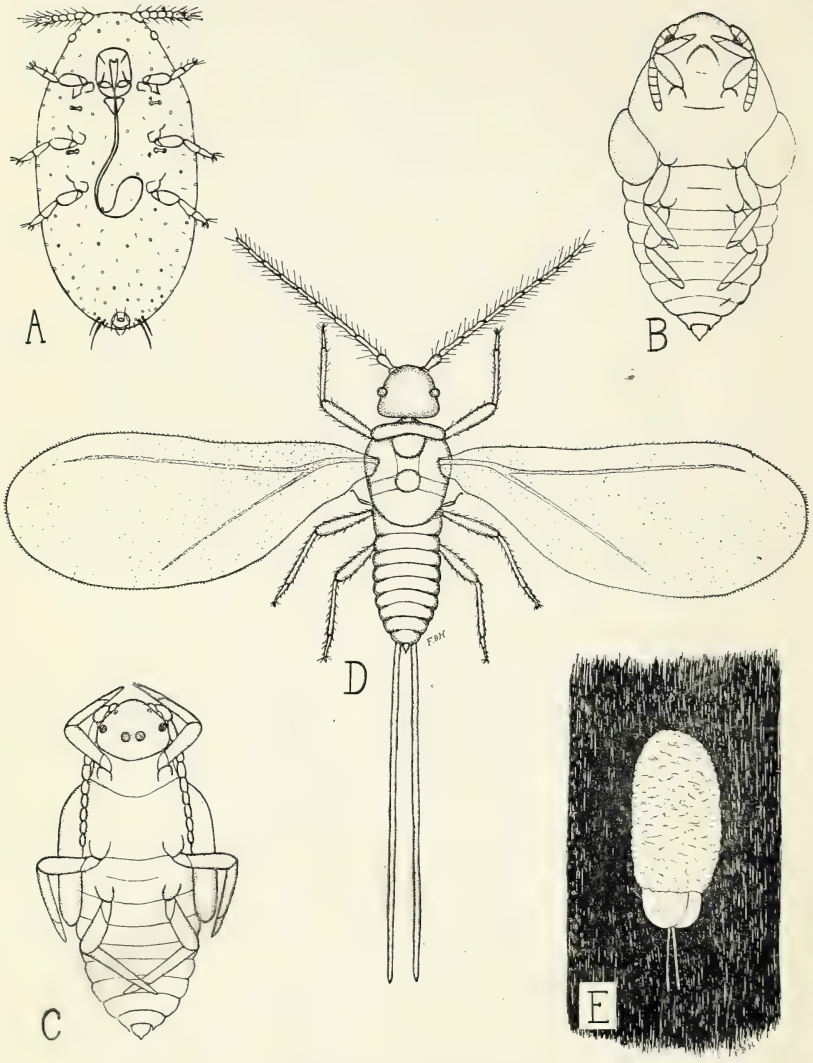
Each female is capable of laying 50 to 100 or more eggs. The greatest number of eggs that has been found within a female at any one time is 105. The eggs are laid slowly, covering a long period of time. They are laid during the warmer part of the day at intervals of 7 to 70 minutes. After laying a series of 5 to 10 eggs, the female ceases oviposition for a day or so and then resumes it.

Most of the embryos in the eggs are deposited tail first, about one-sixth being deposited head first. The head end of the embryo is evidenced by the two black eyes which are visible through the egg membrane. By a series of contractions of the abdomen, the egg is forced out until entirely free from the body of the adult. These eggs are oblong oval when first deposited, but flatten out somewhat before the rupturing of the membrane occurs.



THE CYPRESS BARK SCALE.

A, Antennæ: 1, adult male; 2, first-stage larva; 3, adult female (same as second-stage larva); *B*, Tip of abdomen, showing anal rings and caudal setæ: 1, first-stage larva; 2, second-stage male; 3, second-stage female; 4, adult female; *C*: 1, leg of adult female; 2, tip of tarsus and claw; *D*, Ducts and pores: 1, large pore and tubular duct of adult female; 2, small pore and tubular duct of second-stage male; 3, spine; 4, trilocular pore; 5, quinquelocular pore.



THE CYPRESS BARK SCALE.

A, Male larva, second instar (× 50) (male and female first-instar larvæ are identical); *B*, male prepupa (× 50); *C*, male pupa (× 50); *D*, male adult (× 50); *E*, male adult ready to emerge from cocoon.

About 15 minutes after the eggs are deposited, the embryo starts a series of convulsions and after considerable struggling ruptures the membrane inclosing it. The ruptured membrane is pushed down over the abdomen and the larva, which is usually on its back, begins waving its legs about in the air. It usually takes this larva 20 to 30 minutes to free itself from the membrane, and after exercising its legs for 30 or 40 minutes it finally gets to its feet and crawls away (Pl. IV, *E*). The larva quite often is stuck to the next expelled egg and may be held out in space for some time, but the struggles of one or the other finally allow the feet of the larva to touch foundation, where it soon makes use of them.

MIGRATION.

The larvæ become very active soon after exclusion and begin searching for a suitable spot upon which to locate. The majority of them immediately work down into the bark crevices or under the cottony secretions of the parent females, where they become attached. Some seem more fastidious than others and travel farther in search of newer feeding grounds. Recently hatched larvæ when placed upon favorable young trees do not travel far, and usually settle down after investigating two or three crevices in the bark.

Larvæ placed upon paper were able to travel considerable distances. (See fig. 2.) The average rate of travel for six larvæ was 54.25 cm. per hour, which they were able to maintain for several hours. The greatest distance traveled by one larva was 174 cm. in two hours. One larva, after traveling 124.46 cm. in four hours, apparently put its last efforts into trying to pierce the paper with its proboscis. Table I gives the time, distance, and rate per hour traveled by six cypress bark scale larvæ on black paper for the first few hours of their migration. Black paper was used in order to facilitate following the tiny pale larvæ in their wanderings. When white paper was used the larvæ were soon lost. There seemed to be a slight phototropism in the case of most larvæ, the majority of them finally wandering toward the light.

TABLE I.—*Record of travel of six first-instar larvæ of the cypress bark scale on rather smooth black paper.*

No.	Time.	Distance.	Rate per hour.
	Hours.	*Cm.*	*Cm.*
1	1.5	109.22	72.81
2	2.5	143.51	57.40
3	4.0	124.46	31.11
4	2.0	173.99	86.99
5	2.0	142.24	71.12
6	2.0	66.04	33.02
Average.	2.333	126.577	54.255

Larvæ isolated in vials, immediately after hatching, lived for two and three days. Living for this length of time and traveling at the above rate of speed during only the warmer parts of the day, larvæ could go considerable distances in search of proper food. In this way larvæ are able to migrate from one tree to another in closely planted hedges or windbreaks. During this migratory period, larvæ are also likely to be transported short distances by dropping from high

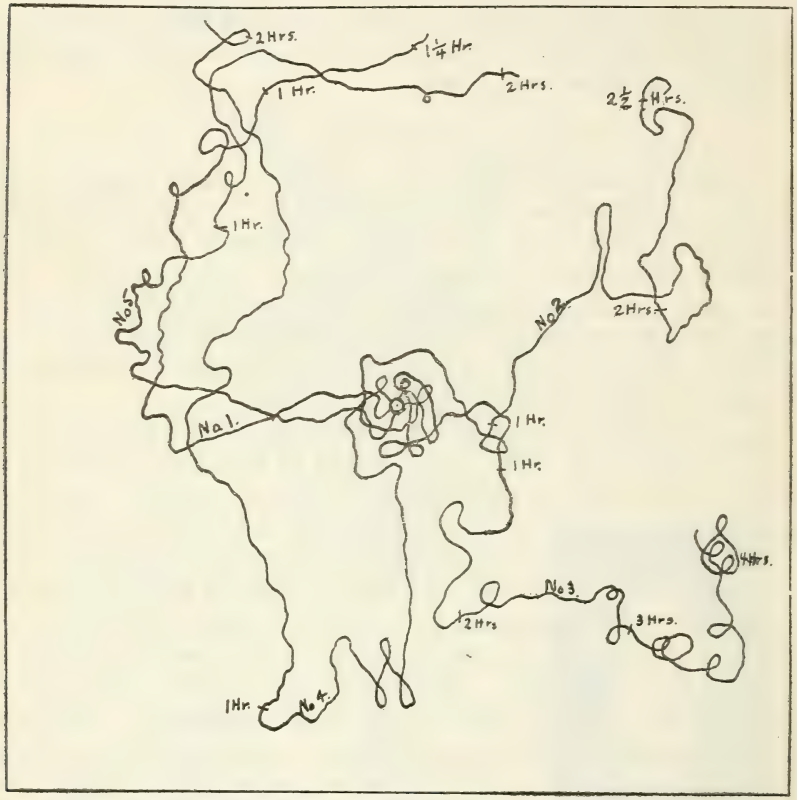


FIG. 2.—Tracings of five first-instar larvæ of the cypress bark scale during migration. Reduced 5½ times. All were started from the same center.

branches and being carried by the wind, and for longer distances by animate agencies, such as insects, birds, and animals.

ATTACHMENT.

As soon as a larva finds a suitable crevice or a protected area in the bark, it thrusts its proboscis into the bark tissues, where it remains permanently. Larvæ have not been known to remove themselves from this first location to another after once becoming attached. Larvæ which have become detached somewhat later in life are able to crawl about feebly, but finally die without being able to attach

themselves again. Although the legs are retained throughout the full lifetime, they are of no further use to the female larva except to aid in removing the cast skins when molting.

Larvæ will attach themselves on twigs as small as one-fourth inch in diameter and on trunks a foot or more in diameter, provided the bark is not too thick to be pierced with their proboscides. A few scale insects have been found infesting the smooth trunk of seedlings less than one-half inch in diameter, but rough bark is essential to a heavy infestation. The deeper the larvæ are able to go into the crevices the more satisfied they appear to be. They have been found so well secreted in crevices that it would seem there was no room left for their future growth, and much less any chance of mating, particularly after being enveloped with a white flocculent secretion.

LARVA.

FIRST INSTAR.

Immediately after attachment the larva begins enveloping itself with this white cotton until entirely hidden from view. A drop of honeydew, resembling pitch, is emitted by some larvæ, especially on vigorous trees, during the first few weeks after attachment.

Growth starts immediately after attachment and is practically constant throughout the whole instar. The larva at the end of the instar is very similar to those just hatched, except that the former are larger, somewhat broader in proportion to their length, and slightly darker in color.

At the end of the first instar, the larva molts, the skin being pushed down off the tip of the abdomen. From 40 to 44 days were required to complete the first instar in the few cases observed.

SECOND INSTAR.

There is very little development during the second stage. The female larva secretes more waxy cotton and changes in size and shape until it resembles the adult female. After a period of from one to two months the second molt occurs and the larva becomes an immature adult.

The male larva increases in size and becomes yellowish white in color. It takes on a firmer and trimmer appearance. After a slightly shorter time than that required by the female larva, the male larva detaches itself and crawls about in search of a favorable place in which to pupate. It may pick a spot under some cotton or in a curl of the outer bark. Cocoons have also been found in the cast skins of coccinellid larvæ and in the ruptured bodies of dead female scale insects.

Here the male larva proceeds to spin a cocoon, secreting cottony wax from the small ducts which occur on both the dorsum and venter of the body, turning over and over in the operation. The cotton secreted is finer than that secreted by the female larva, as would be expected because of the smaller ducts on the male.

It requires three or four days to complete the cocoon. After a day or two of inactivity, the larva molts to a prepupa, pushing the cast skin out through a slit which is in the rear end of the cocoon.

MALE PREPUPA AND PUPA.

The male from now on is without mouth parts, and during this dormant period is an inactive creature, capable only of feebly waving its front legs and wriggling its abdomen when disturbed.

The male remains in this stage from 10 to 15 days, and with this molt becomes a true pupa, greatly resembling the adult male. As in the previous stage, the pupa is inactive. Normally the same length of time is required for this stage as for the previous one. A few pupæ have been found hibernating in the colder Sierras.

ADULT.

MALE.

When the pupal skin is cast, the male's wings are extended to their full size and then folded, one over the other, upon its back. As soon as the wax filaments have grown to their full length, which requires from 30 minutes to several hours, the male backs out of the cocoon and becomes very active. It immediately begins searching for a mate. The length of life of the male is never more than one or two days and death occurs very soon after mating.

FEMALE.

The color of the female becomes darker after the second and last molt, and upon becoming heavily chitinized is a dark reddish brown. After mating the body increases considerably in size, becoming nearly globular. Inside the female's body may be found a large number of eggs in different stages of development. The body still is covered quite thoroughly with cotton and deeply hidden in the bark crevices. Upon becoming an adult a new supply of coarser threads of wax is excreted. After depositing the eggs, an act which covers a considerable period of time, the female shrivels and dies, nothing but the chitinized skin remaining. If the host plant is still alive, this vacancy is soon filled by a female of the next generation.

SEASONAL HISTORY.

(Fig. 3.)

There is but one generation per year, the limits of which are not very definite. The males appear in the fall, being most abundant in

October and November. These mate and die in a few days. At this time most of the females have cast their last skin and are about one-half grown.

The winter is passed as adult females, with no very definite period of hibernation in the lower altitudes. In the Sierra Nevadas there is a more definite period of hibernation and the generations are more even. The female larvæ become adults somewhat earlier in the fall. When the cold weather strikes them, development becomes very slow. In December females are found containing a few eggs. These develop during the winter and early spring.

Oviposition begins on the first warm days of spring and lasts throughout the summer, beginning about April 1 and terminating the latter part of September. In the fall the females, having com-

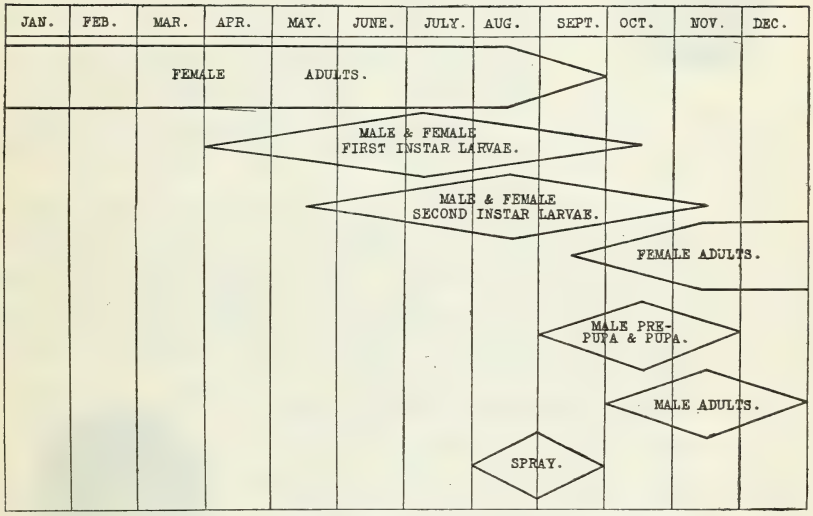


FIG. 3.—Seasonal history diagram of the cypress bark scale.

pleted oviposition, shrivel and die. By this time the young females of the next generation are quite well developed, thus assuring the presence of adult females during the whole year.

The larvæ issue from the eggs 30 or 40 minutes after deposition and soon attach themselves. Larvæ of the first instar may be found from April to the middle of October, second-instar larvæ from the middle of May to the middle of November, and adult females from about September 15 to the following September. Male prepupæ and pupæ may be found in September, October, and November, and adults in October, November, and December. A male pupa was found hibernating in the Sierra Nevadas. A few scattering first and second stage larvæ may be found during the winter in the milder climate near the coast.

PREDACIOUS AND PARASITIC ENEMIES.

There are several coccinellids which aid in the control of the cypress bark scale. None of them is aggressive enough, however, to affect its abundance very materially.

A very small ladybird, *Nipus biplagiatus* Casey (fig. 4), is the most abundant and widespread enemy of the scale. This is a sturdy little beetle, about 1.3 mm. in length, brownish black, with a lighter amber spot in the center of each elytron. It is generally present wherever the scale insect is to be found. On one side of a cypress limb in a space 3½ by 24 inches (84 square inches), there were found 46 specimens of this coccinellid and in certain parts of this area there were as many as four beetles to the square inch. There were undoubtedly still more out of sight under the bark scales. Very few of the larvæ of this beetle were seen but this may be accounted for by their extremely small size and their pale brown color.

FIG. 4.—*Nipus biplagiatus*, a coccinellid enemy of the cypress bark scale. × 25.

A small black nitidulid beetle, *Cybocephalus californicus* Horn (fig. 5), is very abundant and is sometimes confused with the above coccinellid. It is, however, slightly smaller, shiny black, with more delicate legs, and of a more compact globose form. This beetle has not been seen actually feeding upon the scale insect, yet it is believed to be an aggressive predacious enemy. It is always found about the scale insect, and often with its head in the bark crevices as if feeding upon the scale insect. The larva of this beetle is small and white and not easily found.

FIG. 5.—*Cybocephalus californicus*, a nitidulid beetle always found about the cypress bark scale. × 25.

The twice-stabbed ladybird, *Chilocorus bivulnerus* Muls., is an abundant and aggressive predator upon the cypress bark scale. This beetle is often found upon cypress, feeding upon this insect pest.

The common black-spotted red ladybird, *Hippodamia convergens* Guérin, has been found a few times feeding upon the scale. As this beetle breeds in great numbers in the Sierra Nevadas, it probably feeds upon the scale on incense cedar in its native haunt.

Larvæ of the common brown lacewing, *Sympherobius angustus* Banks, are often found feeding upon the cypress bark scale and aiding materially in retarding its increase and spread.

A few specimens of a small hymenopterous parasite have been reared from caged material of this scale insect. It can not, however,

be considered as of any importance, because of its great scarcity. In all the writer's observations but three scale insects have been found with punctures in them, from which parasites have escaped. Two of them were from Monterey cypress and one from incense cedar in the Sierra Nevadas. The scarcity of this scale insect in the Sierras would indicate that a parasite was quite active upon it. If such is the case, it has not as yet been noted.

CONTROL EXPERIMENTS.

A series of experiments was undertaken in order to find one or more materials capable of reducing the numbers of this very harmful pest. Only those sprays were experimented with which would be able to penetrate well into the crevices of the bark, where many of the scales were located. Oil sprays are the only ones which meet these requirements, consequently no others were tried. The oil sprays are capable of penetrating and creeping into all the tiny cracks and crevices of the bark when properly applied. The higher the gravity of oil used, the better is the penetration.

First, crude-oil emulsion was used, but, being a low-gravity oil, it was unsatisfactory. Next, distillate emulsion was used and, being of somewhat higher gravity, was more satisfactory, but still did not kill more than 40 per cent of the scale insects. Miscible oil No. 1 was next used, being of about 28° Baumé gravity. This used in a 12½ per cent solution was quite satisfactory, destroying from 75 to 90 per cent of the scale insects. A well-known washing powder was tried as an emulsifier with both the emulsion and the miscible oil, but proved of no value, so its use was discontinued.

Carbolic sheep dip was tried out, as this was reported to have very good penetrating powers. This, however, gave only about 30 per cent efficiency and was not used further. Six per cent was the highest used with this, as a higher percentage was believed to be dangerous to the tree. It also made the lungs of the experimenter quite sore.

Next, miscible oil No. 2 was experimented with, for this had the very high gravity of 33° Baumé. A 12½ per cent solution of this proved quite satisfactory, killing a high percentage of the scales and upon second application destroying virtually 100 per cent. Further experiments with this substantiated these results.

In Table II are recorded all spraying experiments performed upon the cypress bark scale. All spraying was done in the warm part of the day, generally in the afternoon, when the trees were dry. The spray was applied very heavily and thoroughly, every part sprayed being completely drenched. In experiments Nos. 19, 20, and 21 (small trees) the entire tree was sprayed; in all others only the trunk, lower limbs, and foliage were sprayed, as the trees were too large to be treated with a hand pump. The cypress foliage

appears to be very resistant, for no burning occurred at any time from the application of the spray.

It was discovered that the small larvæ were much more easily killed than the adult females. All larvæ could not be killed with one spraying, however, on account of the long period of hatching. The last of the brood were not hatched by the time the first were becoming adults; consequently two sprayings were necessary, one to exterminate the early hatched larvæ, the other to exterminate those hatched later.

TABLE II.—*Record of spraying experiments performed upon the cypress bark scale.*

No.	Date.	Formula.	Number of trees.	Per cent of efficiency.	Remarks.
	1918.				
1	Feb. 25	Crude-oil emulsion, 7½ per cen.t	6	0	In shade.
2	Mar. 9	Distillate emulsion, 3 per cent	3	0	Rained that night and following 3 days.
3	...do....	Distillate emulsion, 5 per cent	5	0	Do.
4	Mar. 28	Distillate emulsion, 6 per cent	4	25	In shade.
5	Apr. 10	Distillate emulsion, 7½ per cent	3	20	Warm, dry.
6	...do....	Distillate emulsion, 7½ per cent, and washing powder, 1 pound to 20 gals.	3	20	Do.
7	Apr. 24	Distillate emulsion, 12 per cent	2	40	Do.
8	June 4	Carbolic sheep dip, 3 per cent	3	30	Hot, dry.
9	July 18	Carbolic sheep dip, 6 per cent	2	30	Do.
10	Mar. 28	Miscible oil No. 1, 6 per cent	4	25	Warm, in shade.
11	Mar. 29	Miscible oil No. 1, 6 per cent, and washing powder, 1 to 20.	3	40	Warm, dry.
12	Apr. 24	Miscible oil No. 1, 12½ per cent	2	75	Do.
13	...do....	Miscible oil No. 1, 12½ per cent, and washing powder, 1 to 20.	2	40	Do.
14	Oct. 7	Miscible oil No. 1, 12½ per cent	2	90	Warm, dry; repeat on No. 12.
15	...do....	Miscible oil No. 1, 8 per cent	2	75	Warm, dry; repeat on No. 11.
16	July 18	Miscible oil No. 2, 12½ per cent	2	75	Warm, dry; killed 50 per cent adults and 99 per cent larvæ.
17	Oct. 7	.....do.....	1	75	Warm, dry; rained 2 days ago.
18	...do....	.....do.....	1	100	Rained 2 days ago; repeat on 1 tree No. 16.
19	Oct. 26	.....do.....	38	80	Hedge of young trees.
20	Oct. 28	.....do.....	39	80	Do.
21	...do....	.....do.....	1	85	Repeat on tree No. 38 of Experiment No. 19.

In experiments Nos. 1 to 7, percentages are of actual oil content, not emulsion content.

RECOMMENDATIONS FOR CONTROL.

The following measures are recommended for the control of the scale insect.

Cut out all dying trees or limbs of trees beyond saving and destroy them in order to reduce all possible sources of infestation.

Purchase clean nursery stock for planting. If the stock is infested, return it to the nursery and demand clean stock to replace it.

Most fruit growers now realize that spraying is necessary for the maintenance of healthy trees and the production of clean fruit. Most people, however, still believe that a shade tree should always be able

to take care of itself. One can not hope to maintain healthful, vigorous, shade and ornamental trees without proper care and occasional spraying.

Infested trees should be sprayed twice in the fall, once in August or the first part of September and again in the latter part of September. This is to kill the larvæ before they become mature. The proper dates to spray may vary slightly in different localities and with different seasons, in which case certain phenological events may be relied upon. The first spraying should be done when the fruit of the French prune (the common variety planted throughout the State) becomes blue or first begins to fall from the tree. The second spraying should be done from one to two weeks after the last prunes have been harvested. If but one application is attempted, spray in the middle of September or when the maximum number of prunes are falling from the trees, as this would be the best time to kill the greatest number of larvæ.

The only satisfactory material to be used is a 12½ per cent solution of a high gravity miscible oil (33° Baumé). The proportions are as follows:

	Part.
Miscible oil (33° Baumé)	1
Water	7

Put the requisite amount of oil in the pail or barrel to be used and add about one-fifth that amount of water. After some stirring this will become a thick creamy liquid, whereupon the remaining amount of water may be added with constant stirring. This should be continually agitated while being applied.

The ordinary barrel or bucket pump will serve very well in applying the spray to small trees. A good power apparatus, however, is necessary in order to compel the spray to reach to the top of large trees or to penetrate through the heavy foliage of thick hedges.

Thoroughness of the application can not be overemphasized. It is absolutely necessary for successful control. See that the spray comes in contact with every twig and that all the larger limbs and trunks are thoroughly drenched.

When planting trees not intended for trimmed hedges or windbreaks, leave a wide space between each individual. It is a common fault to plant all sorts of trees too closely. Cypresses planted purely for ornament should be fully 40 or 50 feet apart. Trees already planted can be thinned out to this distance. This will retard the spread of the insect and give more nourishment to each tree left. The addition of fertilizers and water about the base of infested trees will also aid in overcoming the effects of the scale insect.

In badly infested regions it is not advisable to replant cypresses. There are many other species of trees which are less prone to infestation and are just as ornamental, which should be planted. There are other trees and plants, also, which make effective trimmed hedges.

The common privet (*Ligustrum vulgare* Linn.) forms an admirable hedge. The holly-leaf cherry (*Prunus ilicifolia* Walp.), *Atriplex canescens* James, and *Pittosporum* spp. also are recommended. Pittosporum, however, is subject to attacks from scale insects which are just as difficult to control as the cypress bark scale. The Oriental and Italian cypresses form quite effective coniferous hedges, the latter being tall and slender. Certain forms of red cedar (*Juniperus virginiana* Linn.) are used as trimmed hedges in certain sections of the United States. If this proves to be immune to the scale insect, it should be a very good substitute for the Monterey cypress.

SUMMARY.

The main cause of the browning and death of so many cypress trees, hedges, and windbreaks throughout California is the cypress bark scale, *Ehrhornia cupressi*.

It was found in the course of a thorough investigation that the scale insect was not a native of the Monterey cypress, but of the incense cedar which occurs in the mountains of California, Nevada, and southern Oregon. From this host it has probably spread to the Monterey cypress by the transportation of incense-cedar seedlings or rustic timber to the regions infested.

The characteristic injury caused by this insect begins to show on one or two limbs and slowly spreads to the rest of the tree. The foliage turns first yellow, then red or brown, giving the tree a very dilapidated appearance. After a few years the whole tree dies.

The food plants of the cypress bark scale are Monterey cypress, Arizona cypress, Guadalupe cypress, and incense cedar.

The larvæ are small oval bodies, pale yellow in color, which are active for a short time after hatching. They attach themselves in crevices of the bark and are soon enveloped in a white cottony secretion. As they reach maturity they become reddish-brown in color and nearly spherical in shape.

Oviposition begins in the spring and lasts throughout the summer. The eggs hatch into larvæ in less than an hour and soon attach themselves. The females reach maturity in the fall and hibernate over the winter, starting oviposition in the spring. The males appear in the late fall or early winter to mate and die.

There are several insects which prey upon the cypress bark scale, none of which, however, is abundant enough to control the scale insect. Consequently remedial measures have to be adopted. A 12½ per cent solution of a high-gravity miscible oil is the spray recommended. To obtain complete control it is necessary to spray twice in the early fall, once in August and once in the latter part of September.